Improved Nanodots Could Be Key to Future Data Storage

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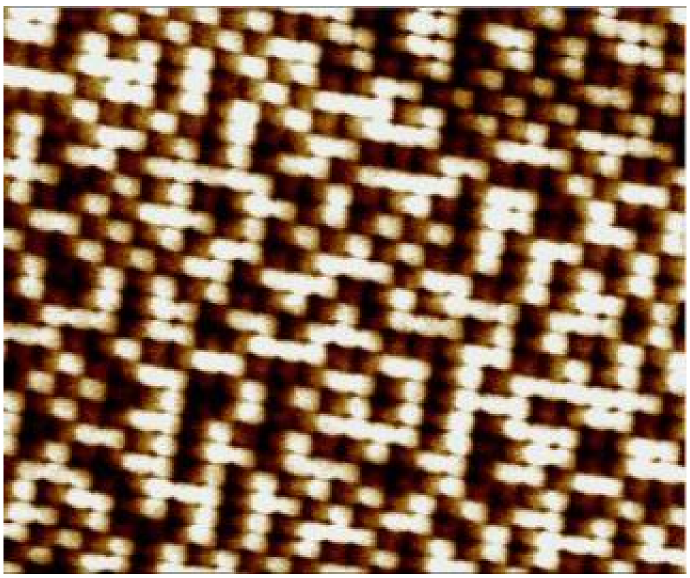

False-color image of 50-nanometer cobalt-palladium nanodots made with a magnetic force microscope provides both topographic and magnetic profiles. The darker dots are magnetized in the up direction (representing 1 in binary code) and the lighter dots are pointing down (representing 0). Credit: NIST

The massive global challenge of storing digital data--storage needs reportedly double every year--may be met with a tiny yet powerful solution: magnetic particles just a few billionths of a meter across. This idea is looking better than ever now that researchers at the National Institute of Standards and Technology (NIST) and collaborators have made nanodot arrays that respond to magnetic fields with record levels of uniformity.

The work enhances prospects for commercially viable nanodot drives with at least 100 times the capacity of today's hard disk drives.

A nanodot has north and south poles like a tiny bar magnet and switches back and forth (or between 0 and 1) in response to a strong magnetic field. Generally, the smaller the dot, the stronger the field required to induce the switch. Until now researchers have been unable to understand and control a wide variation in nanodot switching response. As described in a new paper,* the NIST team significantly reduced the variation to less than 5 percent of the average switching field and also identified what is believed to be the key cause of variability--the design of the multilayer films that serve as the starting material for the nanodots.

Nanodots, as small as 50 nanometers (nm) wide, were fabricated using electron beam lithography to pattern multilayer thin films. The key was to first lay down a tantalum "seed layer" just a few nanometers thick when making a multilayer film of alternating layers of cobalt and palladium on a silicon wafer. The seed layer can alter the strain, orientation or texture of the film. By making and comparing different types of multilayer stacks, the researchers were able to isolate the effects of different seed layers on switching behavior. They also were able to eliminate factors previously suspected to be critical, such as lithographic variations, nanodot shape or crystal grain boundaries.

Nanodots are one of two major approaches being pursued around the world as possible means of boosting the density of magnetic data storage. The other involves using a laser to heat and switch individual bits. The ultimate solution may be a combination of the two approaches, because heat reduces the strength of the magnetic field needed to switch nanodots, according to Justin Shaw, lead author of the new paper. Considerable work still needs to be done to make this type of patterned media commercially viable: Dot dimensions need to be reduced to below 10 nm; techniques to affordably fabricate quadrillions of dots per disk need to be developed; and new methods to track, read, and write these nanoscale bits need to be devised. The NIST authors collaborated with scientists at the University of Arizona, where some of the nanodot samples were made.

Citation: J.M. Shaw, W.H. Rippard, S.E. Russek, T. Reith and C.M. Falco. 2007. Origins of switching field distributions in perpendicular magnetic nanodot arrays. *Journal of Applied Physics*. 101, 023909 (2007), Jan. 15.

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